The GlobAEROSOL dataset:
Using a multi-instrument satellite aerosol dataset

Gareth Thomas[1],
Caroline Poulsen[2], Richard Siddans[2], Elisa Carboni[1], Andy Sayer[1], Don Grainger[1]

[1] Atmospheric, Oceanic and Planetary Physics, University of Oxford
[2] Space Science and Technology Department, Rutherford Appleton Laboratory

Introduction

The GlobAEROSOL project was an ESA Data User Element programme which produced a 12 year (1995 – 2007) aerosol global dataset of aerosol properties from European satellite sensors. The aim of the project was to produce a consistent record, suitable for use for model intercomparisons, from the ATSR-2 , AATSR, MERIS and SEVIRI sensors, and as such can be considered a direct progenitor to the upcoming ESA Climate Change Initiative aerosol project.

This work concentrates on GlobAEROSOL data from the 2nd Along Track Scanning Radiometer (ATSR-2) and the Advanced ATSR instruments. Together ATSR-2 and AATSR provide a near continuous record from 1995 to the present, with future continuation from the SLSTR instrument to be launched on Sentinel 3. The dual view measurement system of the ATSR instruments make them well suited to aerosol retrieval and their good calibration and stability offers the hope of consistent data between instruments.

The GlobAEROSOL (A)ATSR product

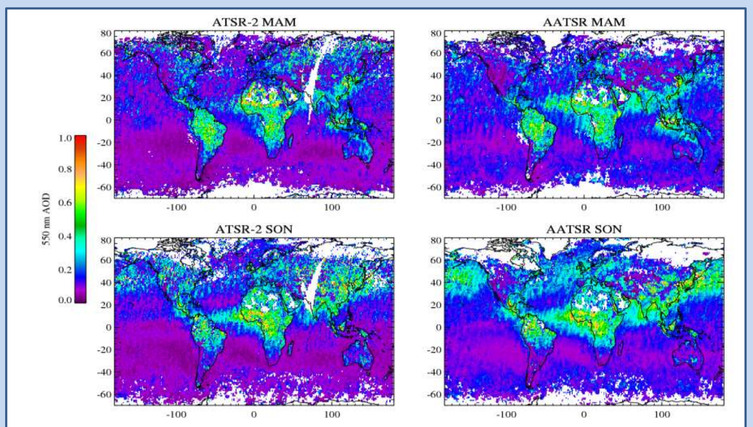

Fig.1. Seasonal maps of AOD from 2002 from both ATSR-2 and AATSR. Despite the similarity of the instruments, there are significant differences in the products. ATSR-2 data has only been included if all shortwave channels were active (i.e. low data-rate modes have been removed)

The ATSR-2 and AATSR GlobAEROSOL products were produced with the same version of the Oxford-RAL Aerosol and Cloud (ORAC) optimal estimation retrieval scheme. Details of this algorithm are given by Thomas et al. (2009). The scheme uses a forward model based on the DISORT code coupled to a BRDF description of the surface reflectance to simulate TOA reflectances measured in the 0.55, 0.67, 0.87 and 1.6 µm channels in both forward (zenith angle ~55°) and nadir views. The Levenberg-Marquardt algorithm is then used to match the modelled reflectances to those measured by the instrument as a function of the aerosol optical depth (AOD) and effective radius, as well as the bi-hemispherical surface reflectance in each channel. The optimal estimation framework allows inclusion of a priori constraints on the retrieval, which is particularly important for the surface reflectance, where the ratio of the reflectance in the two views is constrained by the MODIS surface BRDF product over land and an ocean surface reflectance model over the sea. This process is repeated for a series of assumed aerosol classes representing background continental, maritime, dust, biomass burning and urban aerosol, providing a limited indication of aerosol type based on the selection of the class that best fits the measurements.

The algorithm applied to ATSR-2 and AATSR was identical, and the AATSR radiances were updated with vicarious calibration corrections provided by Smith et al. (2009).

There are three main differences between ATSR-2 and AATSR which explain the majority of the differences apparent in Fig.1:

- ATSR-2 only provides ~50% of the daily coverage of AATSR, due to the low data-rate modes imposed by the ERS-2 satellite.
- The failure of the 3.7 micron channel of ATSR-2 in 2001 has adversely affected subsequent cloud flagging over land.
- There is a recognised, but little publicised, difference in the absolute calibration of the shortwave channels between ATSR-2 and AATSR (Smith et al. (2009) show AATSR provides relfectances ~0.02 higher than ATSR-2 at in channels 1 -3).

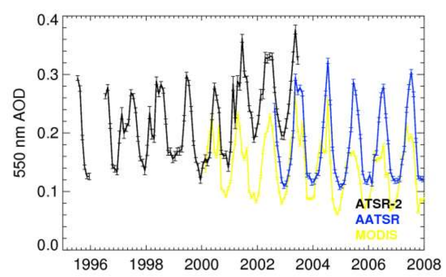

Fig.2. Monthly mean AOD over North America. The effect of the ATSR-2 3.7 µm channel failure can be seen from 2001 onwards as an elevated average AOD due to increased cloud contamination.

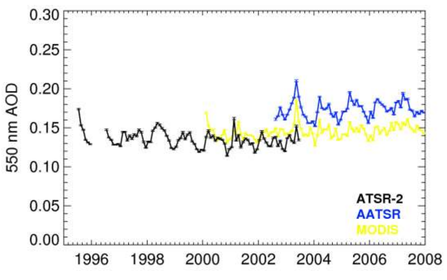

Fig.3. Monthly mean AOD over the ocean (between 60 N & S). Due to the low signal strength over the oceans, the effect of the calibration differences between the two ATSR instruments is most apparent here.

On monthly timescales the difference introduced by the low data rate modes has found to be minimal, as the instruments are still sampling very similar air masses. The second two differences have a significant impact however, as is shown in Fig. 2 and 3 (for reference, equivalent time series for MODIS Terra AOD is included in these figures).

A preliminary evaluation has been performed to determine whether the discrepancy in GlobAEROSOL AODs due to calibration differences between ATSR-2 and AATSR can be corrected. Validation of GlobAEROSOL against AERONET (Poulsen et al. 2009) show that AATSR AOD has a positive bias. Thus we here correct AATSR AOD to match the (generally lower) ATSR-2 value.

A linear least-absolute-deviate fit between log(AOD) between the two instruments (ORAC retrieves AOD in $\log_{10}$ space) provides a correction function to bring AATSR into line with ATSR-2 of:

$$AOD^* = (1.6 \pm 0.1)\ AOD^{(1.40 \pm 0.01)} \qquad (1)$$

The uncertainty given for each coefficient is based on their variation when calculated using data from different regions and time periods. The robustness of this relationship shows that there is a consistent systematic difference between the two data sets.

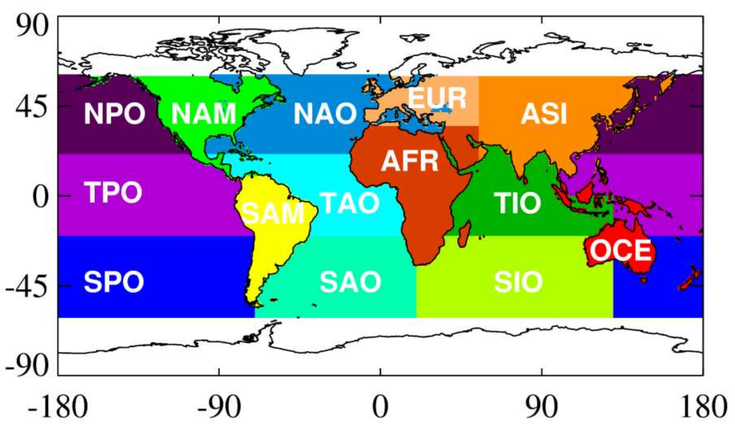

Fig.4. Regions, based on those defined by Quaas et al. (2008), used in regional comparisons.

Contact: gthomas@atm.ox.ac.uk

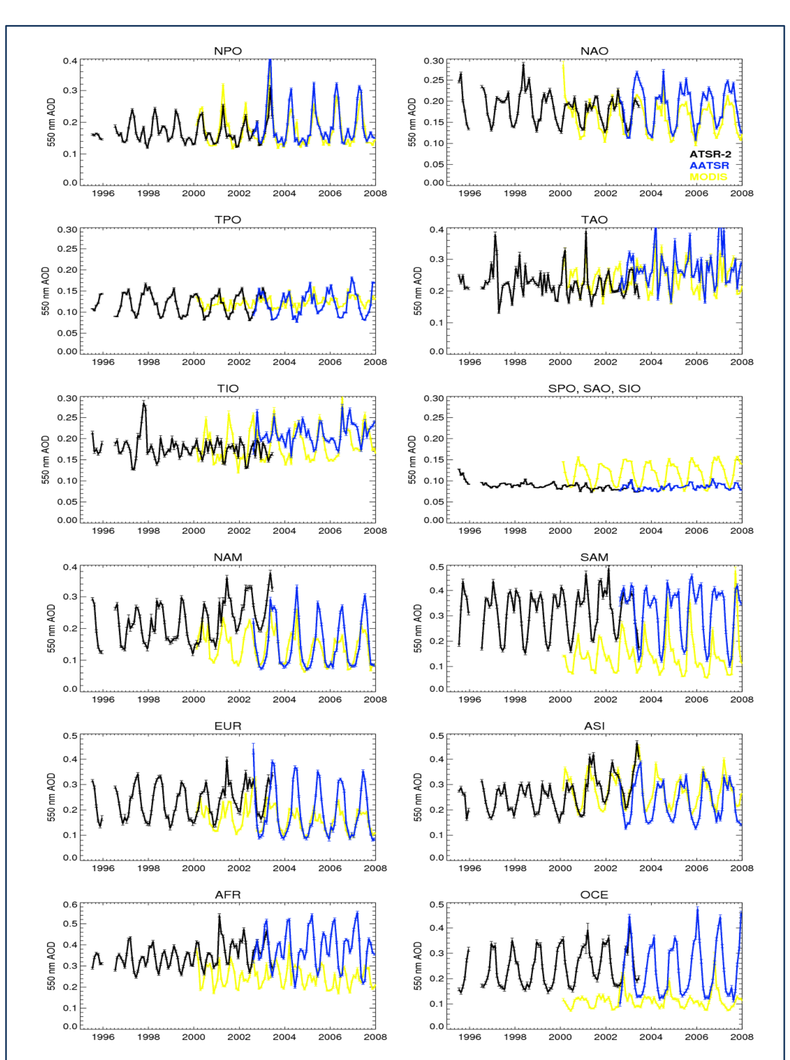

Fig.5. AOD time series for all of the regions shown in Fig.4, with AATSR data corrected using Eqn.1. Again, MODIS AOD data is also included for comparison.

Correcting AATSR AODs using the Eqn.1 improves the continuity between the two ATSR time series for most regions. There is still room for improvement however:

- Some regions still show an offset between the two instruments (e.g. NAM and TIO)
- The seasonal cycle of the corrected AATSR data is slightly larger than that displayed by both ATSR-2 and MODIS in some regions.

Conclusion and future work

Comparison of AOD from ATSR-2 and AATSR GlobAEROSOL products has revealed a systematic bias between the two products. It is suggested that this is the result of the bias known to exist between ATSR-2 and AATSR radiance measurements.

A simple empirical correction to AATSR AODs, based on a linear fit between log(AOD) from both instruments has been found to drastically improve the consistency of the two datasets on a regional, monthly-mean scale.

Although this simple correction cannot be considered to have completely rectified the discrepancies, it is suggestive that, given the long term stability of the ATSR instruments' measurements, it should be possible to correct for the observed discrepancies and produce a consistent 12 year time series from the GlobAEROSOL dataset. It is hoped that comparison with ground truth AOD from AERONET will aid in this task.

For future products that make use of the ATSR instrument series, and in particular the upcoming ESA Climate Change Initiative aerosol project, it is essential that consistent Level 1 radiance data is available.

References

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